HCAL System Reliability

H C A L

CMS HCAL ESR
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Outline

- Disclaimer
- Reliability requirements
- Theory behind time estimates
- Reliability preproduction study
- Production tests
- 2002 test beam experience
- Summary and plans

Disclaimer

- This warranty does not cover the Photo Detector.
- I'm not going to talk about radiation damage.

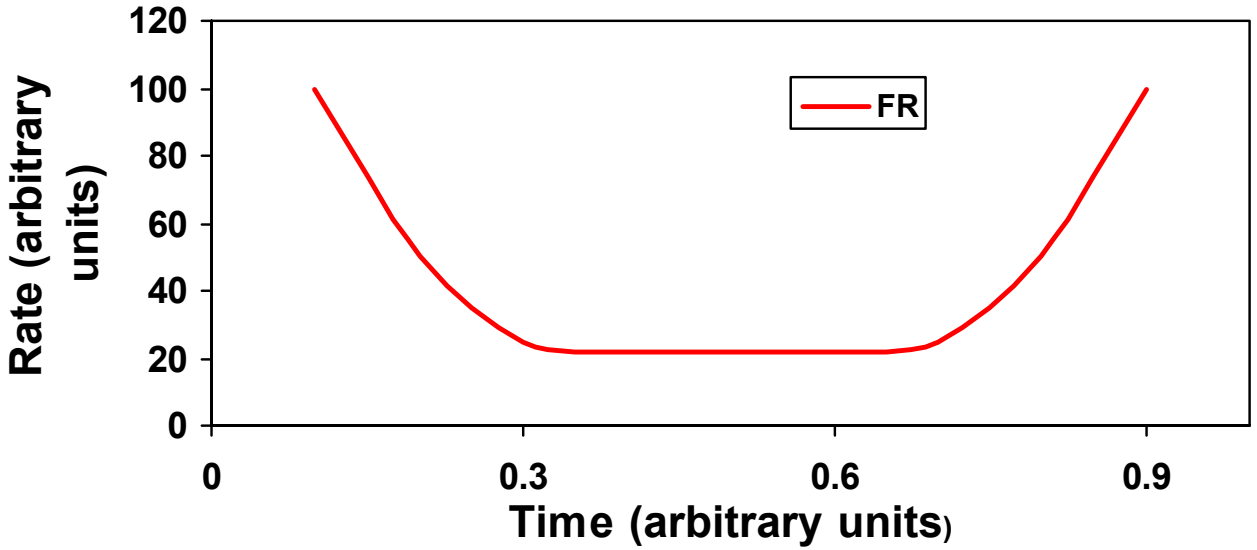
Reliability Requirements

<5% (10?) of dead channels

- **This discussion is concentrated on FE electronics and HV services, LV distribution might need a similar effort to demonstrate its reliability.**
- **There are several possible failure modes that we can tolerate without immediate repair:**
  - Single channel (one QIE chip)
  - Double channel (CCA chip)
  - Triple channel (serial communication)
  - Single board (CCM clock distribution, voltage regulator)
- **Failure of a whole RM opens a 5º crack in the detector and can not be tolerated**

Failure Rate

Typical failure rate looks like that:



- "Early lifetime failure" is addressed by **Burning-in**
- "Random failure rate" and "End of life cycle" are taken care about with **Accelerated aging**

Theory of Accelerated Aging

- Comes from Arrhenius low for the chemical reaction rate.

$Af=\exp(-{}^{Ea}/_{k}({}^{1}/_{T2}-{}^{1}/_{T1}))$

Af is an acceleration factor for two temperatures

- Problem: Activation energy is unknown!
- Solution1: Extract from MIL STD-883 regression table (for microelectronic devices)

Answer: 0.4 eV for Burning-in

1 eV for Accelerated aging

- Solution2: Simplified Protocol for plastic Medical devices (for HV cable)

Answer: ×2 per 10ºC

Reliability Preproduction Study

We plan to go to a 10+ years of operation equivalent with a subset of electronics

- 10 years of LHC is only 5 years under power
- We'll use 1 full RBX for this study (5% = 4 ch.), the CCM should be studied separately). Test is conducted with power on.
- At 30ºC above operating temperature it takes 2 month to get an equivalent of 10 years at 50% duty cycle
- To be sure we are not too close to the "end of life cycle" we'll double that time
- Measurements will be taken after initial burn-in and then after every 2 equivalent years
- 5 QIE cards will be subjected to thermocycling until they die (no less than 10 for a 0º- 70º C swing)

Reliability Preproduction Study II

For a HV cable/distribution chain failure of a single component takes out a full 5º sector out of operation

- There is a spare HV wire in every cable that we can use to bypass a damaged one without recabling
- Two HV Units have been exposed to 50 thermal cycles from +25 to +105°C with no deterioration in leakage current
- The same HV Units will undergo accelerated aging equivalent to 10+10 years (1/2+1/2 month at 105°C)
- One HV cable will be measured for increased leakage at 18 kV (12 kV operating voltage) during a 10+10 year aging test at 80°C (3+3 months) while being stressed at a 25 mm bending radius.

Production Tests

Electronics

- All cards will go through 5÷10 thermal cycles (0÷70°C) without power
- Burn-in test will include 1 week at 30°C above ambient (2 months recommended by MIL STD-883). This can be reconsidered after the preproduction study.

HV Components (not the cable)

- All parts go through 10÷20 thermal cycles (25÷105°C) without power to reveal assembly defects

HV Cable

- Cable undergoes a 20 kV test after installation and after being connected to the RBX (2 hours)

Test Beam Experience

2 Complete RBXs were in operation during the 2002 test beam for 3 month

- No dead channels were observed
- Some deterioration in operating parameters can not be attributed to the electronics aging, rather to the “infant mortality” due to sloppy assembly and not fully developed/implemented grounding/shielding measures
- Very crude processing of the test beam numbers gives us 7% of dead channels after 10 years of calendar LHC

Summary and Plans

- Our current estimates (7%) from the Test Beam are not so bad, but unfortunately statistically not very significant
- We have a positive Lab experience with QIE cards, no failures during extensive handling
- We have some understanding to proceed with further testing

- Signal cables should be thoroughly studied during the RBX accelerated aging test
- We can start with most of the tests in Jan-Feb when necessary equipment will be collected